Alternative Fuel Transit Buses

The Pierce Transit Success Story...

Produced for the U.S. Department of Energy (DOE) by the
National Renewable Energy Laboratory, in cooperation with Battelle

THE PIERCE TRANSIT SUCCESS STORY...

1985
Pierce Transit decides to test alternative fuels, and chooses CNG for its initial operation.

1986
Two "New Look" coaches are converted to operate on dual fuel (diesel and CNG). Mechanics are trained in conversion and drivers are identified to operate the vehicles.

1987
The success of the initial operation leads to the decision to purchase 100-percent-CNG buses.

1988
No bids are made for 100-percent-CNG buses, so Pierce chooses to order CNG/unleaded gasoline buses.

1989
Pierce Transit orders 19 28-foot buses from El Dorado Bus Company. Challenger Energy Products installs the CNG conversion.

Pierce orders 15 100-percent-CNG buses with Cummins L10-240G engines from Bus Industries of America (BIA).

1990
Specifications are developed for a new CNG fueling station. The first CNG El Dorado Bus is delivered in October.

1991
Taking advantage of an Alternative Fuel Initiative Grant from the Federal Transit Administration, Pierce orders 15 more CNG buses from BIA.

Pierce changes the CNG conversion on the El Dorado Bus from the Challenger system to the MOGAS™ system.

The first 100-percent-CNG bus arrives at Pierce Transit in October.

1992
Construction on the fueling station is finished.

Second delivery increases the total number of CNG buses to 30 (excluding bi-fueled El Dorados).

1993
Pierce Transit orders 27 CNG buses from BIA to run the Seattle Express. CNG tanks on these buses are made with carbon fiber, cutting tank weight almost in half.

In April, the original 30 CNG buses reach 1 million miles collectively.

In December, the original 30 CNG buses reach 2 million miles of revenue service.

1994
Seattle Express buses with Cummins L10-260G engines arrive at Pierce Transit.

1996
Orion Bus Industries is awarded the contract for 15 CNG Orion V buses to be added to Pierce Transit's fleet.

Final Results from the National Renewable Energy Laboratory (NREL) Vehicle Evaluation Program for Alternative Fuel Transit Buses indicate that the costs for the CNG and diesel control buses are nearly the same.

In 1986, Pierce Transit made a commitment to the future of the transportation industry and to the environment by deciding to put buses powered by compressed natural gas (CNG) into everyday service. Ten years, a new facility, 58 CNG buses, and countless phone calls later, CNG is no longer a novelty; it's business as usual.

"Sometimes we feel like consultants," says Ron Shipley, Director of Maintenance and originator of Pierce Transit's CNG project."We used to get two or three phone calls a day with questions about our CNG program."

The agency's phones are still ringing. But today, Shipley says, "It's not something new anymore. It's the way we do business."

Based in Tacoma, Washington, Pierce Transit operations cover an area of 450 square miles and a population of approximately 600,000 residents. The agency serves both rural and urban areas, including an express route to Seattle, which is operated exclusively with new CNG buses. The company's fleet includes 193 transit buses, 148 of which are in service at any given time. CNG powers 58 of these buses.

The agency's facilities include a 35,000-square-foot administration building, a 76,000-square-foot maintenance facility, a CNG fast-fill station, 6 transit centers, 152 bus shelters, and 9 park-and-ride locations.

Pierce Transit's first experience with CNG involved converting two GMC "New Look" buses to run on a combination of CNG and diesel. Although this experiment was successful, fuel efficiency was a problem. "In hindsight, whenever you are burning two fuels in the engine, whether you are flipping a switch [to change fuels] or two fuels together, you can't optimize the engine," Shipley says. So the agency began searching for an original equipment manufacturer (OEM) that would help develop 100-percent-CNG engines.

After discovering that no major manufacturers were prepared to make a commitment to CNG, Pierce Transit ordered 19 small CNG coaches for rural routes from El Dorado Bus Company. Challenger CNG conversions were added at a cost of about $15,000 per bus to Ford 460 electronic fuel injection gasoline engines. The company replaced this conversion system a

Mandated by Congress and directed by the U.S. Department of Energy (DOE), the Vehicle Evaluation Program collects data on alternative fuel use by light-duty vehicles, heavy trucks, and heavy transit buses in the United States. Designated by DOE as the program manager, NREL collects and analyzes alternative fuel vehicle data in its Alternative Fuels Data Center (AFDC). The AFDC provides objective alternative fuel information to interested organizations, such as private industry, government agencies, and research institutions. NREL also publishes reports describing events and conclusions related to alternative fuel vehicles and alternative fuels.

short time later with a MOGAS™ system to solve hard starting, backfiring, and hesitation problems.

In 1989, Pierce Transit found its OEM in Cummins Engine Company, and the agency ordered 15 buses from Orion Bus Industries (formerly Bus Industries of America), equipped with Cummins L10-240G CNG engines. Since then, the agency has received 15 more L10-240G buses as well as 27 Orion V buses powered by the L10-260G, the so-called "Seattle Express" buses. Pierce Transit will receive 15 more Orion buses within the next year, each of which will be equipped with new Cummins L10-280G engines.

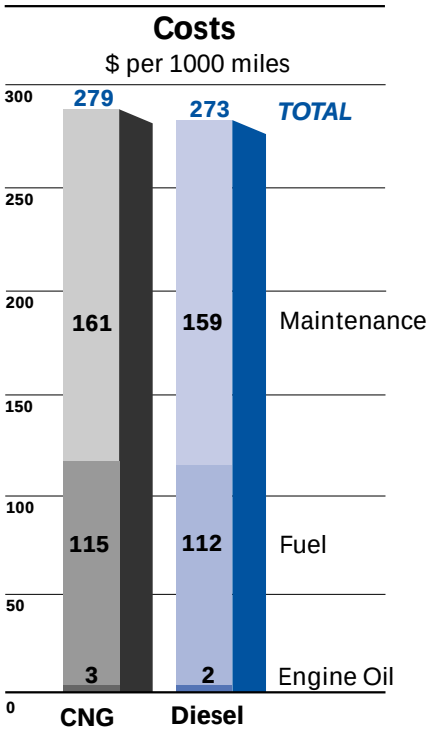
Pierce Transit has participated in the National Renewable Energy Laboratory's (NREL) Alternative Fuels Transit Bus Evaluation Program since the program's inception in 1993.

NREL's data clearly support Ron Shipley's evaluation of Pierce Transit's alternative fuel operations: CNG works at Pierce Transit. This case study outlines the company's success and how it was achieved.

Costs

A common argument among those who choose not to use alternative fuel engines is that capital costs for the engines and the vehicles are too high. The buses cost $30,000 to $50,000 more than their diesel counterparts. Most of this additional expense is attributable to the higher cost of CNG engines and natural gas storage cylinders.

"That cost will always be there," Shipley says. "As technology improves we'll see that price come down a little." Shipley estimates that capital costs for CNG and diesel engines will be equal by the end of this decade, but not because CNG engines are getting cheaper. Diesel engine prices will continue to rise because of increasingly stringent environmental standards.



Source: Alternative Fuel Transit Buses, Final Results from the National Renewable Energy Laboratory (NREL) Vehicle Evaluation Program

"Because we have such a high percentage of alternative fuel vehicles, we're able to meet those standards with less involvement in the EPA's certified retrofit/rebuild program for our diesel engines," Shipley says.

Necessary changes to facilities present additional capital costs. Pierce Transit's CNG fueling facility, which was completed in 1992, cost $847,000. The agency also had to add natural gas detectors to its maintenance facilities and modify its ventilation systems at a cost of more than $500,000.

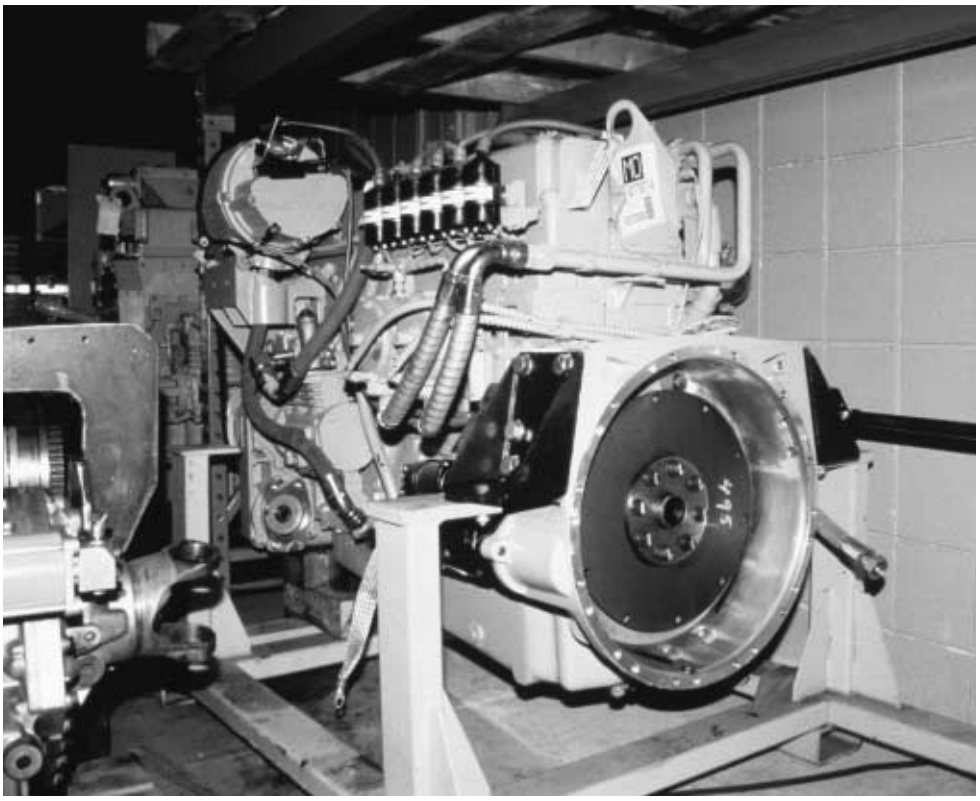
Maintenance costs for the agency's diesel and CNG fleets are nearly equal. "There are still problems with the ignition system, specifically spark plugs and wires," Shipley says, "but electronics are making the engines more reliable, which translates to lower maintenance costs for us."

The most intriguing cost comparison between Pierce Transit's diesel and CNG fleets comes in the area of fuel. During the NREL evaluation program, Pierce Transit paid $0.52 per diesel equivalent gallon for CNG and $0.65 per gallon for diesel. In the fall of 1996, the agency will begin buying CNG as a commodity. Pierce Transit will be able to buy a high volume of CNG directly from

natural gas suppliers rather than from Washington Natural Gas, a state-regulated utility. This will cut the cost of CNG by more than one-third —from $0.52 to $0.29 per equivalent gallon.

CNG prices are also much more stable than diesel prices. This protects Pierce Transit when the price of petroleum products increases, as it did earlier this year.

As NREL data indicate, after 10 years of work in CNG, Pierce Transit has made it to the point where CNG operating costs are almost the same as diesel. The NREL program collected and analyzed operating costs for vehicle maintenance (repairs, inspections, cleaning, and rebuilding costs), and fuels and lubricants. Pierce Transit research indicates that $0.06 must be added to each diesel equivalent gallon of CNG to account for maintenance labor and parts used for the compression station. Operating costs for the agency's CNG fleet were $0.28 per mile, compared to $0.27 for diesel. With the new lower CNG fuel prices, CNG operating costs at Pierce Transit should be significantly lower than diesel.



Reliability

The reliability of Pierce Transit's CNG fleet is illustrated by examining the number of road calls per 1000 miles and usage comparisons between CNG and diesel fleets.

The average distance between road calls is a measurement of how many times a bus develops a problem while in service. The numbers for Pierce Transit's CNG and diesel fleets are identical, and this is true even if you examine only engine- and fuel-system-related road calls—the types of road calls that may be caused by the use of an alternative fuel.

The CNG fleet also gets a lot of usage. On average, the agency's CNG buses travel 4,500 miles per month, compared to 5,000 miles per month for the diesel fleet.

Fuel Efficiency

The agency's CNG engines are about 20 percent less fuel efficient than their diesel counterparts. This can be attributed to the lower compression ratios and throttling losses of the CNG engines and to slight differences in duty cycles between the two fleets. The CNG tanks on the agency's newest buses are made of a composite material, which reduces the total weight of the tanks and mounting hardware from nearly 3,900 pounds to about 2,500 pounds. This weight reduction along with new electronic engine controls should have a positive effect on fuel efficiency.

Road Calls per 1000 Miles for Diesel and CNG Buses

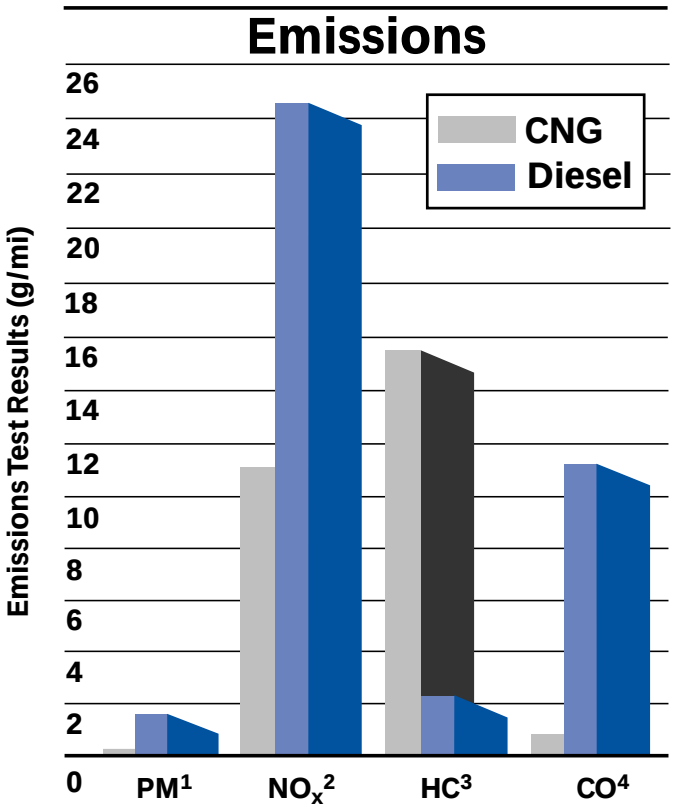
Total Road Calls	0.21
Engine/Fuel-System-Related Road Calls	0.11

Source: Alternative Fuel Transit Buses, Final Results from the National Renewable Energy Laboratory (NREL) Vehicle Evaluation Program

Emissions

Members of West Virginia University's Department of Mechanical and Aerospace Engineering have measured Pierce Transit's CNG fleet for emissions data using a chassis dynamometer. The university tested these vehicles using the standard Central Business District (CBD) test cycle, which was designed to simulate typical route speeds, loads, and conditions. Results are highly dependent on proper engine tuning and the condition of the engine's catalytic converter, regulators, and mixing valves.

Dynamometer test results for CNG and diesel buses at Pierce Transit show that particulate matter was found to be below the detectable limits of the instrumentation, which indicates a significant advantage for CNG. Hydrocarbon (HC) levels from the CNG buses were significantly higher than HC levels for diesels. Ninety to 95 percent of the total HC count may be attributable to methane, which is considered nonreactive in the formation of atmospheric ozone, and, therefore, is not used by the EPA as a basis for emissions regulations.



[1]Particulate matter.
[2]Nitrogen oxides are the principal pollutants that react with volatile organic compounds to form ozone when exposed to sunlight.
[3]Hydrocarbons are composed of combinations of carbon and hydrogen.
[4]Carbon monoxide is emitted directly into exhaust gases as a result of the incomplete combustion of hydrocarbons.

Source: Alternative Fuel Transit Buses, Final Results from the National Renewable Energy Laboratory (NREL) Vehicle Evaluation Program

Lessons Learned

You need to make the commitment if you want alternative fuels to make a difference.

- ***Commit resources if you want to see benefits.*** Your fleet must include a significant number of alternative fuel vehicles to benefit from the economies of scale experienced at Pierce Transit. This also requires committed management and strong individual leadership.
- ***Keep your employees informed about the fuel and the technology.*** Training for vehicle operators, maintenance teams, and fueling crews will promote the transition and lessen anxiety about new technology.
- ***Work with the experts to solve your problems.*** Cummins Engine Company, Orion Bus Industries, the Gas Research Institute, and the Natural Gas Vehicle Coalition provided invaluable service to Pierce Transit. Demonstrating the effectiveness of the fuel, the engines, and buses was a team effort.
- ***Base your decision on all aspects of the financial evidence.*** The initial investment in alternative fuel vehicles requires a substantial financial commitment. However, the long range view indicates that operations, fuel, and maintenance costs are *not* substantially higher. Data also indicate that a natural gas engine does not require modifications to meet current and future environmental regulations.

Future Trends

Ten years ago, Pierce Transit took a big leap into the future of the transportation industry. The relatively small agency has pushed the development of CNG technology and has applied that technology to everyday business.

"For those that get into natural gas, it has to be more than a purely economic decision," Shipley says. "If petroleum products get rationed, as has happened in the past, then I can't provide service, and I need to be there for our customers."

Environmental concerns should also play a role in the decision to turn to alternative fuels. "They are cleaning up diesel engines, but we know that natural gas is a very clean fuel, and we know what it can do," Shipley says.

By 2003, if the agency's replacement schedule continues at its current pace, all of Pierce Transit's buses will be powered by CNG engines.

Future Trends

Natural Gas Engines for the Transit Market

Cummins Engine Company

- Cummins B5.9G
- Cummins C8.3G
- Cummins L10-280G/300G

Detroit Diesel Corporation

- DDC Series 30G
- DDC Series 50G

If you're only concerned about the bottom line, diesel is still cheap by world standards. My gut feeling is that the day of reckoning is in the not-so-distant future. If you think you're going to be in business 10 years from now, you should be looking at some other way to do business that provides fuel price stability and availability as well as environmental improvements.—*Ron Shipley*

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For more information and for copies of program reports, visit the Alternative Fuels Data Center on the World Wide Web at ***http://www.afdc.doe.gov****, or call the Alternative Fuels Hotline at* ***1-800-423-1DOE.***

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